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PDS4 – Some Principles for Agile Data Curation

AGU 2015 - IN22A-04
15 December 2015

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Introduction

- Agile Data Curation
- Architecture
- Information Model
- Information Model-Driven Architecture

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Agile Data Curation

- PDS4, a research data management and curation system for NASA's Planetary Science Archive, was developed with agile data curation[1] principles in mind.
  - *adaptive planning*
  - *early delivery*
  - *evolutionary development*
  - *continuous improvement*
  - *rapid and flexible response to change*
- Using these principles an architectural process was used to plan, design, and construct a system that met both the desired functional and technical requirements and the community's expectations.
- The resulting architecture
  - *produces better research data products*
  - *uses less resources (time, effort, and money)*
  - *maximizes product usefulness for current and future scientists.*

[1] Young et al., Taking Another Look at the Data Management Life Cycle: Deconstruction, Agile, and Community, AGU 2014

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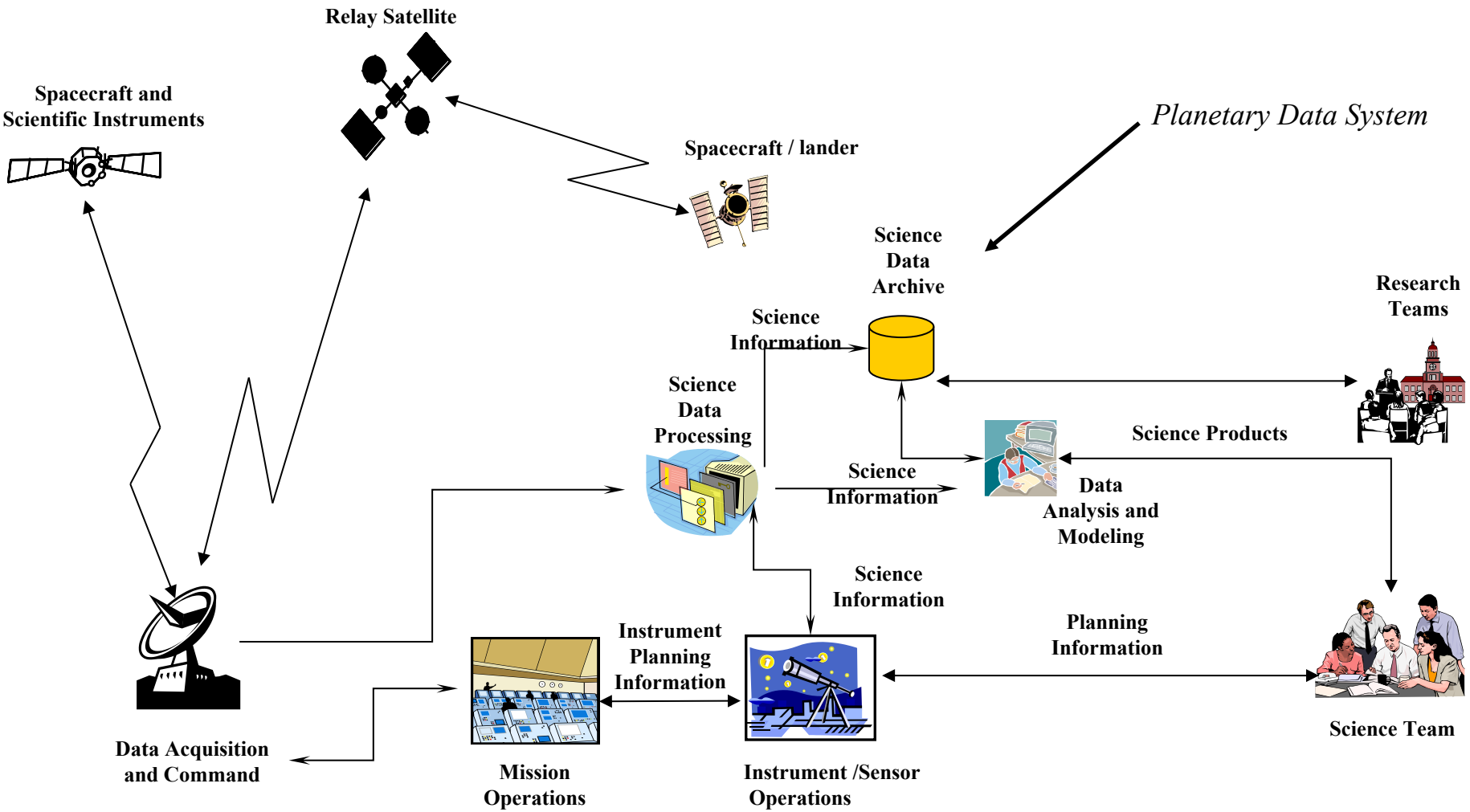
Reference Architecture



Credit: CCSDS Reference Architecture for Space Information Management

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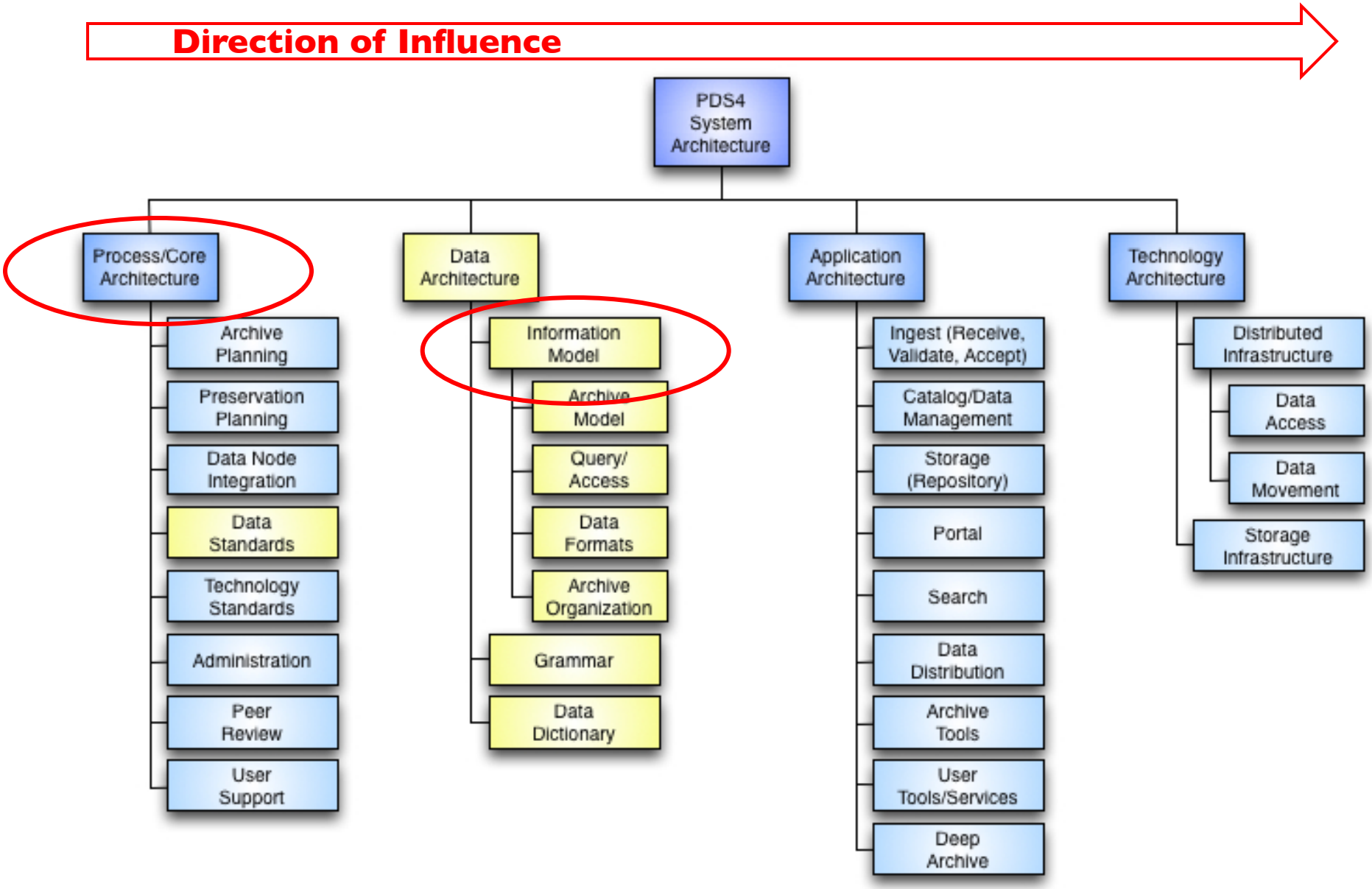
System Architecture



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Information Model - Definition

- "An information model is a representation of concepts, relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse." [1]

- It provides a sharable, stable, and organized structure of information requirements or knowledge for the domain context.

[1] Lee, Y.T. 1999. Information Modeling: From Design To Implementation. In Proceedings of the Second World Manufacturing Congress, ed. S. Nahavandi and M. Saadat, 315-321. Canada/Switzerland: International Computer Science Conventions.

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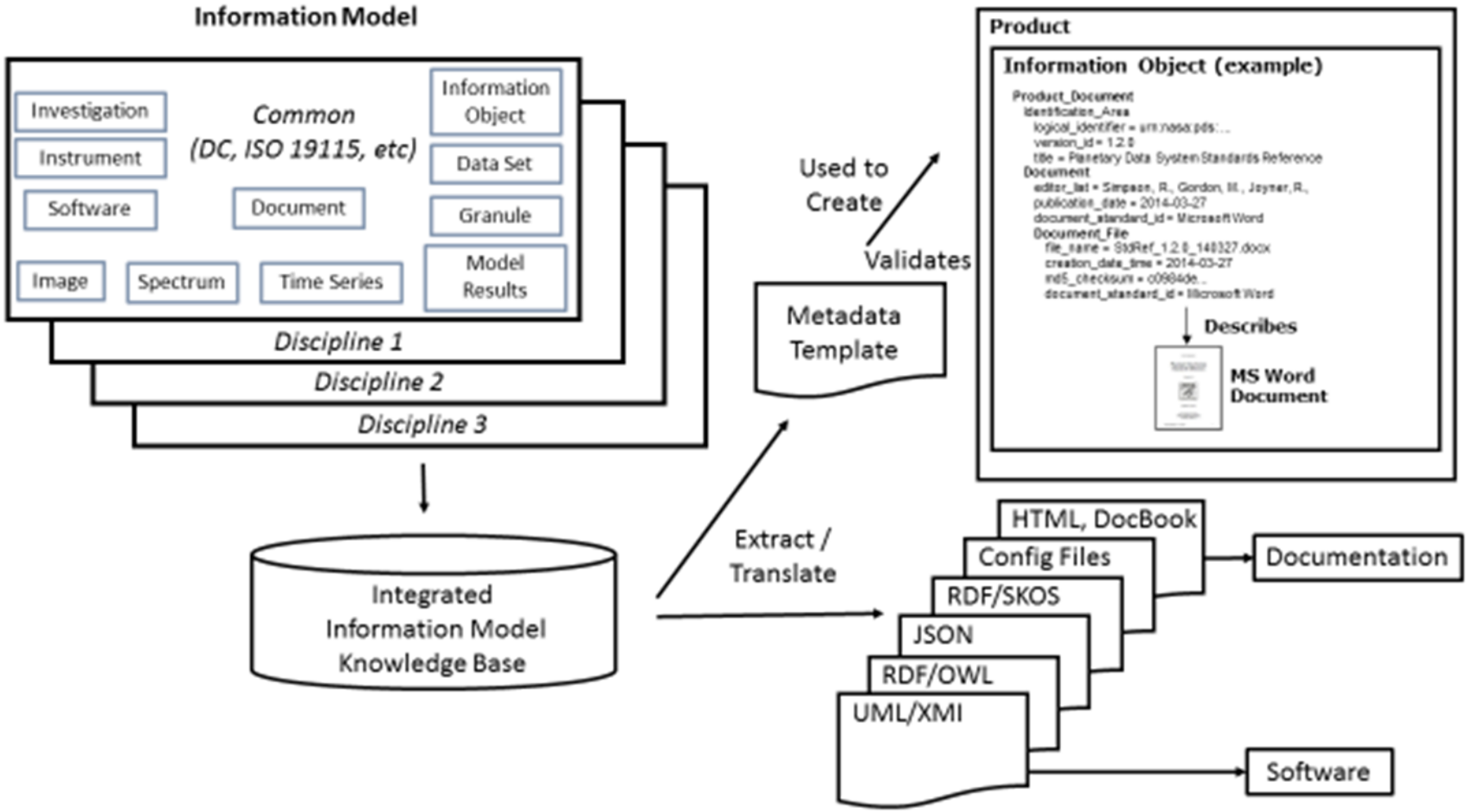
Information Model in Context



Information Modeling Principles

- The Information Model is developed and maintained independent of the infrastructure's process, application and technology architectures.
  - *The information model needs to evolve independent of the information technology*
  - *Disentangles the model from the implementation*
  - *Provides a sharable, stable, and formal set of data requirements*
- The information architecture is based on an ontology-based information model developed to leverage best practices from standard reference models for digital archives, digital object registries, and metadata registries
- Captures domain knowledge from a panel of planetary science domain experts.
  - *The modeling language should be formal, standardized, and broadly used and accepted*
  - *The language should be more expressive than the other languages in the system's framework.*

Purpose of the Information Model

- Defines the data structure (format)
- Defines the interpretation of the data
- Defines the context within which the data was captured, processed, and archived
- Defines the relationships between the data

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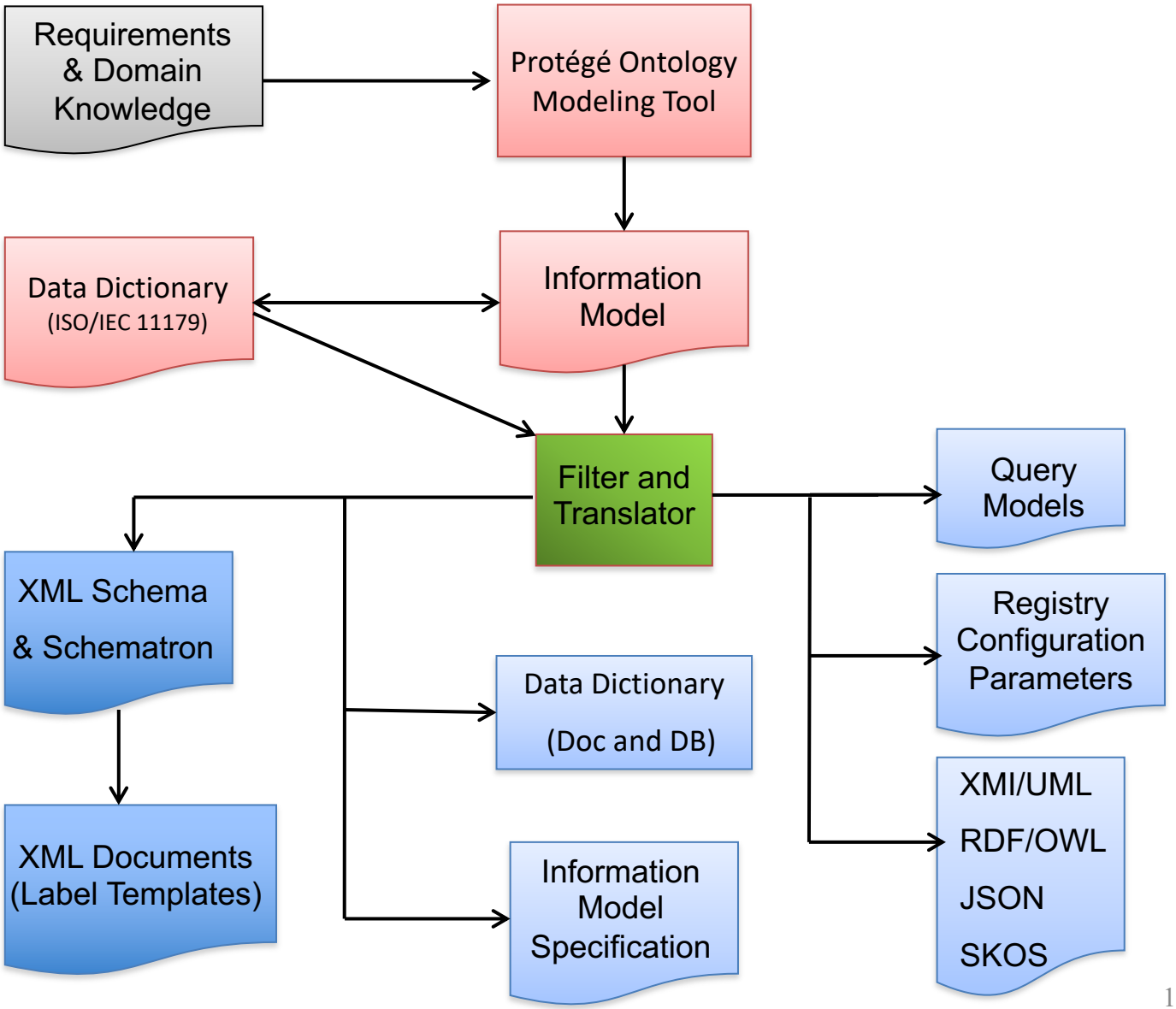
Life-Cycle of the Information Model

- Define the scope and purpose of the model.
- Institute governance over the elements of the model
  - *Decide on the number of levels of control required*
  - *Allow controlled evolution at all levels.*
- Acquire domain knowledge from discipline experts
  - *Capture the knowledge in a modeling tool*
  - *Formalize the knowledge in a commonly acceptable and highly expressive language*
  - *Test early and frequently to determine the applicability and desired level of detail.*
- Use the model anytime and anywhere the knowledge is applicable
  - *Filter out the appropriate aspects of the model*
  - *Translate the filtered results to the most appropriate language for the purpose.*

1..*

Knowledge Data Flow



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- Adaptive planning
  - Software and services are designed to respond to the information model.
  - An extensible model was designed to accommodate new features.
  - Controlled adaptation occurs at all levels of governance but most easily at the mission/project level
  - Knowledge acquisition keeps the domain experts “in-the-loop”.

- Evolutionary development
  - Prior to V1.0, versions of the model were frequently released to allow users to test and respond.
  - After V1.0, new versions of the model are released regularly with Change Control Board (CCB) approved changes.
  - The information, process, and technology components of the architecture evolve independently and at different speeds.

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- Early delivery
  - First drafts of design elements were/are generated upon request for review and comment.
  - Versions of the model were/are made available upon request for review and testing.
  - Software and services were/are built, configured, and deployed regularly for review and testing.

- Continuous improvement
  - Stable versions of the model are released with regularly scheduled system builds.
  - The change control process in concert with the multi-level governance structure is used to manage change.

Agile Curation in Practice

- Rapid and flexible response to change
  - *Changes at the mission/project level is localized to allow rapid and flexible response.*
  - *Multi-level governance provides appropriate controls.*
  - *Independent information, process, and technology architectures allow localized changes.*

Summary

- PDS4, a research data management and curation system for NASA's Planetary Science Archive, was developed with agile data curation principles in mind.

- The Information System's architecture allows independent development and evolution of the information, application, and technology components.

- A model-driven architecture, extensive involvement of domain experts, early delivery for review and testing, and continuous improvement have resulted in a set of standards, services, and software now being adopted by both the NASA and International planetary science community.

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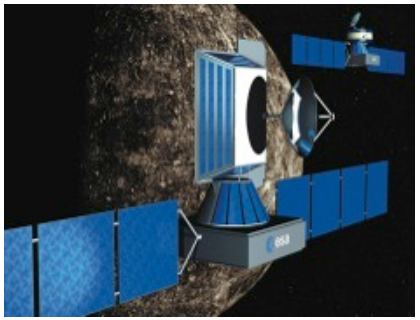
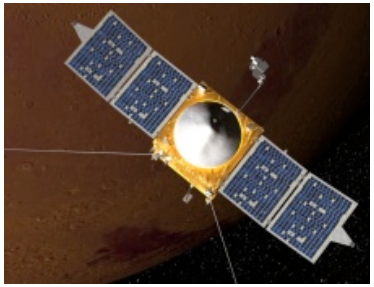
Adoption of PDS4

InSight (NASA)

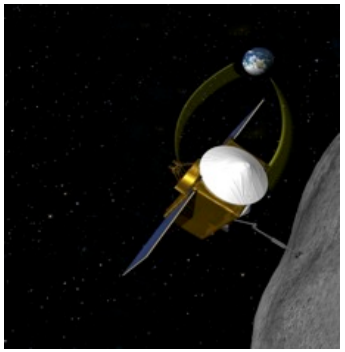


BepiColumbo (ESA/JAXA)

Planetary Data System Version 4
International, distributed, model-driven data architecture for capturing, managing and distributing planetary science data results to the world-wide science community.*
2000: 4 TBs; 2014: 720 TBs



MAVEN (NASA)



Osiris-REx (NASA)

LADEE (NASA)

ExoMars (ESA)

Return

* Endorsed by the **International Planetary Data Alliance** in July 2012 – https://planetarydata.org/documents/steering-committee/ipda-endorsements-recommendations-and-actions

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Thank you!

This research was carried out by the Jet Propulsion Laboratory,
managed by the California Institute of Technology
under a contract with the National Aeronautics and Space Administration.

Adopted Standards

- Uses the OAIS ***Information Object*** concept exclusively and recursively
  - ***Data Object*** – *Digital, Physical, and Conceptual*
  - ***Representation Information*** – *Describes the Data Object*

- Best practices from the digital archive, object registry, metadata data registry, information architecture, data exchange reference models were used.
  - *ISO 14721:2003 - Open Archival Information System (OAIS) Reference Model - Provides a standard for information objects.*
  - *ISO/IEC 11179:3 Registry Metamodel and Basic Attributes specification - Adopted for the data dictionary schema.*
  - *Reference Architecture for Space Information Management (RASIM) - CCSDS 312-0.G-1 – Provides the overarching architectural principles.*
  - *W3C XML (Extensible Markup Language) - Rules for encoding documents electronically.*
  - *W3C XML schema - Type description language for XML documents.*
  - *Electronic Business XML (ebXML) federated registry/repository information model – Provides a standard to support federated registry/repository functions*
  - *RDF/RDFS/XML - RDF is a standard model for data interchange on the Web.*